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THE ACCURACY OF PRE-TENDER BUILDING PRICE FORECASTS: AN ANALYSIS OF USA DATA

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ABSTRACT

For client expenditure management, risk analysis demands good estimates of the range of possible expenditures likely to occur and their probability of occurrence, while risk management is aided by reducing the range of possibilities.

This paper describes the analysis of a new and updated data set of the pre-tender estimating performance of a USA consulting organisation. It is shown that, with a coefficient of variation of 7.82%, the organisation is the leading non-contractor of those surveyed to date. The analysis then continues to seek a means of improving the estimating performance further by the empirical identification of factors influencing forecasting accuracy. The result of this is to show that, after partialling out the effects of confounding variables, year by year changes account for all the systematic errors that could be detected. These changes are then shown to be significantly correlated with the USA annual inflation rate and a regression model is used to examine the possible effects of adjusting for this in the estimation process.

Keywords: Accuracy, pre-tender forecasts, building prices, market conditions

INTRODUCTION

One of the most important aspects of the construction procurement process is the management of client (owner) expenditure. This is normally done as a form of budgetary control, involving the setting of realistic project budgets and monitoring of client expenditures throughout the procurement period. In a purely deterministic world, this would mean the careful and accurate costing of the construction implications of design decisions and, ideally, taking into account possible trade-offs against any indirect value effects such as time for completion, construction quality, resale or letting values. The practical situation, however, is almost completely nondeterministic. Client requirements evolve out of vague notions of what is needed and what can be achieved, in terms of facilities, finance. Similarly, and often in parallel, construction design also evolves out of the manipulation of, for example, pure spaces, images. Even when the design is finalised and construction is under way, unanticipated events occur on site in the form of such matters as ground problems, buildability and programming problems. In the presence of such a degree of uncertainty, the business of client expenditure management may be more akin to gambling than conventional textbook production planning.

Risk management, which includes aspects of risk analysis, seems to offer at least a partial solution. On the assumption that *the degree* of uncertainties, in the form of probabilities of each of the range of possible outcomes, is known, a battery of management options are available for its treatment. For client expenditure management, risk analysis demands good estimates of the range of possible expenditures likely to occur and their probability of occurrence, while risk management is aided by reducing the range of possibilities.

One aspect of client expenditure management that has received some attention by researchers is the accuracy of pre-tender building price forecasting, also variously known as pre-tender estimating, tender price prediction and conceptual or detailed estimating. The prime motivating force for this has been to identify, and correct for, systematic errors (inaccuracy, i.e. bias and inconsistency) in forecasts – in statistical terms, to find unbiased, most efficient, estimators. Several empirical studies have been reported aimed at identifying causal variables. In every case there has been a strong urge to generalise. By their very nature, however, all have been forced to rely on the availability of retrospective data. This has resulted in a difference of variables used in the analyses. Recent work by Gunner (1997), reported in Gunner and Skitmore (1999), has revisited all these previous analyses, finding a high level of intercorrelation among the various causal variables studied, concluding that generalisation may well be possible once the confounding effects of the intercorrelated variables are removed.

In analysing a new set of USA data, the work described in this paper follows the conventional approach of conducting a series of bivariate analyses of pre-tender forecasting errors with the limited, predetermined, set of candidate causal variables available. In common with several previous similar analyses, significant systematic bias and inconsistency results are obtained for several of the candidate variables. The analysis then continues to examine the effects of partialling out each variable in turn. The result of this is to show that the results change dramatically when the effects of Type, Size and Year are partialled out. This analysis also confirms the observations by made by Gunner (1997) and Gunner and Skitmore (1999) and identifies the Year as being the underlying variable responsible for systematic bias and inconsistency in forecasting by cost consultants.

DATA

The data were obtained from a private firm of cost consultants (Hanscomb Associates) practising in the USA. They comprise a sample of pretender estimates and lowest tender values for 217 building projects, totalling over US$5000 million at 1992 prices, over the period 1980 to 1992 (Appendix A). The project values cover a considerable range, starting from US$37,005 to US$400,444,000. Thirty-four specific building types are included and cover the major areas of medical projects, housing, civil works, educational and correctional facilities, offices, car parking and commercial and industrial buildings. A mix of public, private and military projects make up the data set. All the prices were rebased to 1992 by a suitable tender price index.

Table 1: Most accurate pre-tender estimating organisations

Rank	Organisation	Location	Period	N	Average Error (%)	Coefficient of Variation
1	Contractor[1]	USA	1960s	76	-0.77	5.58
2	Contractor[2]	UK	1979	36	1.29	5.88
3	Contractor[3]	USA	1960s	130	0.25	6.98
4	Hanscomb[4]	USA	1973-5	62		7.71
5	**Hanscomb**	**USA**	**1980-92**	**217**	**5.19**	**7.82**
6	Levett and Bailey[5]	Singapore	1980-91	86	3.47	8.46
7	QS Office[6]	UK	pre1984	55	3.72	9.37
8	PW QS office[7]	Australia	1970s	153	5.85	9.73
9	Contractor[8]	USA	1960s	50	2.40	10.05
10	QS Office[6]	UK	pre1984	62	2.89	10.88
11	County Council[9]	UK	1980s	61	12.77	11.00
12	QS Office[6]	UK	pre1984	89	-0.33	11.29
13	QS Office[6]	UK	pre1984	222	2.61	11.50
14	QS Office[6]	UK	pre1984	62	-5.76	11.68
15	QS Office[6]	UK	pre1984	115	4.38	12.22
16	County Council[l0]	UK	1971-7	63		c12.50
17	PW Dept[11]	Belgium	1971-4	132	-5.17	13.13
18	QS Office[6]	Singapore	1980s	88	-0.18	14.13
19	County Council[13]	UK	1975-8	103	11.50	c15.00
20	QS Office[6]	UK	1978	310	5.86	15.52
21	City Council[13]	UK	1983-7	33	-4.91	18.11
22	PW Dept[14]	Belgium	1971-4	168	-1.45	18.37
23	Govt Agency[15]	USA	1975-84	292	9.22	23.99
24	Levett and Bailey[16]	Singapore	1980-91	181	10.32	28.30

[1]Broemser (1968) buildings, [2]Skitmore (1986) medium-large buildings, [3]Benjamin (1969) buildings, [4]Hanscomb (formerly Hanscomb Roy Associates) (1976), [5]Gunner (1997) main contracts only, [6]Morrison (1984) public sector buildings, [7]Runeson (1976) mainly housing, [8]Shaffer and Micheau (1971) buildings, [9]Ogunlana (1979) road and transport departments, [10]Flanagan and Norman (1983), [11]McCaffer (1996) buildings., [12]Cheong (1991), [13]Tan (1988), [14]McCaffer (1996) roads, [15]Brown (1981) aeronautical building/engineering work, [16]Gunner (1997) all contracts

Overall, the projects were overestimated by an average of 5.19%, with a standard deviation of 8.23 (7.82% coefficient of variation). Table 1 shows how this compares with the analyses of similar data for other organisations, including contractors (the contractor analysis is of the percentage bid-lowest bid differences on the grounds that contractors' bids are equivalent to consultants' pretender estimates, as both are estimates of the market price). Pairwise analyses of equality of variance (F tests) suggests the existence of five significant groups, or league tables, comprising those organisations ranked 1-6, 7-14, 15-18, 19-22 and 23-24 respectively -

indicating this company's position to be in the top performing group as well as the leading non-contractor of those surveyed to date (as judged by coefficient of variation).

ANALYSIS 1

The data were analysed in respect of four candidate causal (independent) variables: building type (e.g., Educational, Medical, etc.), project size ($ value), year (1980, 1981, etc) and sector (public, private, military). The dependent variable used was the percent difference between the forecasted tender price and the lowest recorded bid for the project (positive values indicate overestimates and negative values indicate underestimates).

The means, standard deviations and coefficients of variation were calculated for the dependent variable for each of the subcategories within each independent variable and the significance of the differences of the means and standard deviations between each subgroup was found via analysis of variance (ANOVA) and Bartlett's χ^2respectively. In the case of the project size, being a natural interval level variable, this was arbitrarily subdivided into a suitable number of price band categories. Significance is tested in all cases at the 5% level.

Tables 2 to 5 summarise the results of the analyses. The significance levels are given in Table 6.

Table 2. Project type results

Project type	Number of projects	Mean error (%)	Standard deviation	Coefficient of variation
1. Education	39	7.12	10.53	9.83
2. Other	35	4.43	6.49	6.22
3. Medical	36	6.88	8.44	7.89
4. Offices	24	3.35	6.12	5.92
5. Correctional	23	4.25	7.86	7.53
6. Industrial	22	4.84	9.66	9.22
7. Civil	13	5.45	5.04	4.78
8. Housing	10	6.72	11.16	10.46
9. Commercial	9	0.70	3.00	2.98
10. Car Parking	6	2.98	6.35	6.16
Total	*217*	*5.19*	*8.23*	*7.82*

Table 3. Project size results

Value range	Number of projects	Mean error (%)	Standard deviation	Coefficient of variation
>$1m	11	4.23	12.17	11.68
$1-2m	14	4.36	11.89	11.39
$2-3m	17	10.16	11.00	9.99
$3-4m	11	3.75	7.65	7.37
$4-5m	11	5.25	7.53	7.15
$5-6m	6	15.69	13.37	11.56
$6-7m	7	8.99	7.10	6.51
$7-8m	7	2.95	4.81	4.67
$8-9m	11	3.81	5.98	5.76
$9-10m	14	3.90	6.73	6.48
$10-15m	26	4.77	7.19	6.86
$15-20m	17	3.86	5.25	5.05
$20-30m	18	7.96	5.57	5.16
$30-40m	12	1.27	5.11	5.05
$40-50m	11	1.93	6.90	6.77
$50-100m	15	4.71	6.88	6.57
<$100m	9	3.74	7.51	7.24
Total	*217*	*5.19*	*8.23*	*7.82*

Table 4. Annual Results

Year	Number of projects	Mean error (%)	Standard deviation	Coefficient of variation
1980	9	8.85	5.45	5.01
1981	3	17.54	5.64	4.80
1982	8	8.21	12.81	11.84
1983	13	4.15	5.55	5.33
1984	18	1.71	5.51	5.42
1985	28	1.09	6.48	6.41
1986	24	5.47	8.49	8.05
1987	36	3.46	7.64	7.38
1988	22	5.86	7.63	7.21
1989	25	6.17	5.62	5.29
1990	20	10.31	11.87	10.76
1991	9	7.00	9.60	8.97
1992	2	2.68	0.82	0.80
Total	*217*	*5.19*	*8.23*	*7.82*

Table 5: Sector results

Sector	Number of projects	Total value (US$ 1992)	Mean error (%)	Standard deviation	Coefficient of variation
Public	109	355,435,000	5.25	7.47	7.10
Private	69	1,076,910,000	4.74	8.95	8.54
Military	39	498,645,000	5.84	9.06	8.56
Total	*217*	*5,129,910,000*	*5.19*	*8.23*	*7.82*

Table 6: Significance levels

Analysis	ANOVA				Bartlett's χ^2		
	F	df_1	df_2	p	χ^2	df	p
Type	0.997	9	207	0.444	28.79	9	0.001
Size	1.757	16	200	0.039	35.73	10	0.005
Year	2.794	12	204	0.002	30.18	12	0.003
Sector	0.230	2	214	0.795	3.64	2	0.162

This indicates the existence of significant difference in forecasting bias (means) between the various size bands of projects and years in which they were forecasted. Significant differences in consistency (standard deviations) of forecasts errors were found between the various types, size bands and years in which they were forecasted.

ANALYSIS 2

Following the finding of Gunner (1997) – that intercorrelations among the independent variables are causing confounding effects, the effects of each independent variable were partialled out in turn prior to bivariate analysis of the remaining independent variables. The partialling was effected by standardising each error value into a z-score, i.e., by subtracting the subgroup mean and dividing by its subgroup standard deviation. The results are summarised in Table 7 where each row of the table gives the results obtained when a variable (*Type* in the first row, *Size* in the second row, etc) is partialled out. The degrees of freedom remain the same as those shown in Table 6.

Table 7: Significance levels after partialling

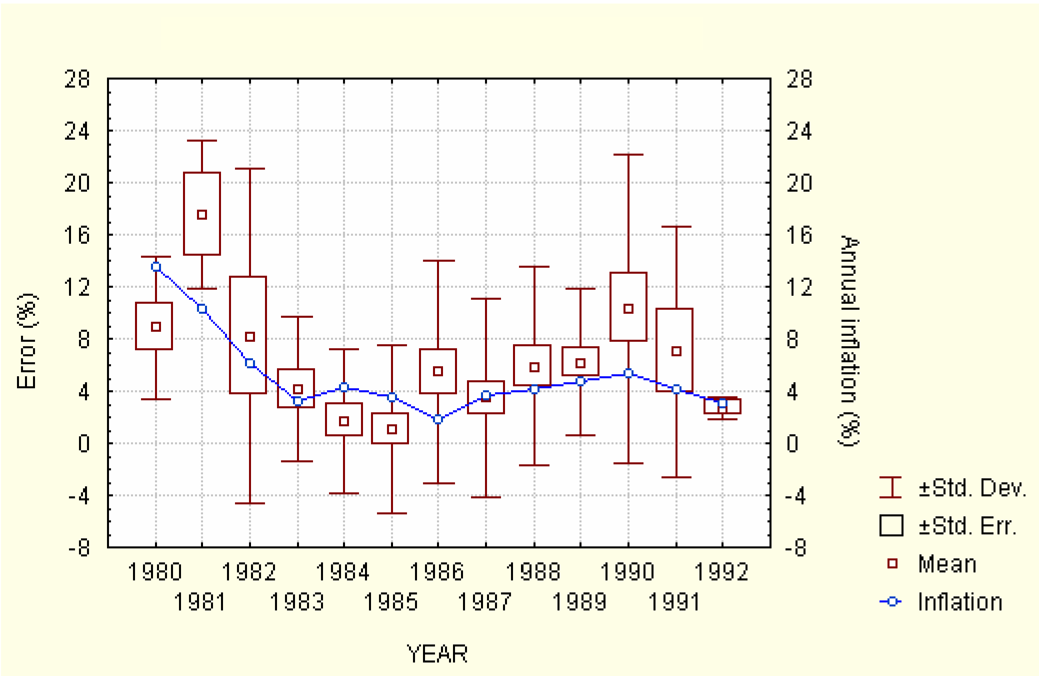
Partialled	Type				Size				Year				Sector			
	ANOVA		Bartlett's χ^2		ANOVA		Bartlett's χ^2		ANOVA		Bartlett's χ^2		ANOVA		Bartlett's χ^2	
variable	F	p	χ^2	p	F	p	χ^2	p	F	p	χ^2	p	F	p	χ^2	p
Type	0.00	1.000	0.00	1.000	1.33	0.180	24.00	0.090	*2.56*	*0.004*	15.05	0.239	0.57	0.569	4.43	0.109
Size	0.86	0.562	14.92	0.093	0.00	1.000	0.00	1.000	*2.72*	*0.002*	5.39	0.921	0.55	0.579	1.23	0.540
Year	0.60	0.796	11.98	0.214	1.38	0.152	26.19	0.051	0.00	1.000	0.00	1.000	0.60	0.552	1.06	0.589
Sector	0.93	0.500	*31.92*	*0.000*	*1.75*	*0.040*	*33.40*	*0.007*	*2.79*	*0.002*	*27.98*	*0.006*	0.00	1.000	0.00	1.000

Inspection of Table 7 clearly shows the existence of confounding effects, the results changing greatly once the Type, Size and Year effects are partialled out. It can also be seen that partialling out the Year effect removes all the significant effects previously recorded for the other variables.

DISCUSSION

Gunner and Skitmore (1999) have suggested that the existence of confounding effects in building price forecasting data may be disguising the fact that a single underlying variable is responsible for the observed systematic bias and inconsistency effects. If this is the case, then the clear candidate for single underlying variable with these data is that of Year as, when the Year effects are removed, all the other effects disappear. In practical terms, therefore, if the cost consultants providing the data were able to somehow adjust their forecasts to allow for the systematic errors due to the year of the forecast, they would automatically and simultaneously

Fig. 1. Distribution of annual forecast errors



remove all other recorded systematic errors. To do this involves examining the yearly errors in greater detail. Fig. 1 shows the results from Table 4 together with the standard error in graphical format. This suggests a clear wave-like pattern with peaks (overestimates) around 1981 and 1990 and a trough around 1985, with abnormally large standard deviations occurring around the peak times.

The USA annual rate of inflation (USA Department of Labor, 1999) over the period is also superimposed on Fig 1 and suggests there may be some relationship with the errors and this is confirmed by a correlation coefficient of 0.203 ($p=0.003$) for the ungrouped data. For the grouped data, the correlation coefficient is 0.673 ($p=0.012$) for the yearly means and inflation rates, and –0.029 ($p=0.925$) for the yearly standard deviations and inflation rates. It is possible that some lagged effect may be taking place and it is suggested that future research should consider the use of time series analysis.

The positive correlation between the forecast errors and the annual inflation rate indicates that projects tend to be overestimated more when inflation is greatest, contrary to the expectation that increased inflation would not be anticipated. Of course, this trend could be adjusted by the use of regression analysis. The regression equation is $E=1.94 + 0.734I$, where E is the percentage error and I the percentage annual inflation rate. The residuals from this model have a standard deviation of 8.06, a slight improvement on the raw error standard deviation of 8.23 reported above. It should be noted, however, that this is a notional improvement based on the analysis of in-sample data and is therefore the maximum that could be achieved. In reality, lack of firm knowledge of the current inflation rate, for example, is likely to make this even slight improvement hardly practicable.

CONCLUSIONS

The construction procurement process relies heavily on an adequate level of financial management to maintain commercial feasibility and smooth operations. Consider a construction project that has an estimated value of ten percent above its estimated procurement cost. On this basis it is rated as feasible and as a result, the procurement process is initiated. Now imagine that the actual procurement cost turns out to be twenty percent higher than that estimated. What is to be done? Of course, the real-world procurement process seeks to fix the actual cost by contractual means as soon as possible so that such poor estimates may be identified and accommodated (by redesign or abandonment) with minimum risk of loss. Even so, with traditional procurement for example, the costs of redesign may be high (not to mention the likely reduction in value and its effects on feasibility) and the costs of abandonment may be just prohibitive at such a late stage. Clearly, estimated outcomes need to be close to actual outcomes to within a few percentage points for decisions based on financial feasibility to make any sense.

This paper has described the analysis of the pre-tender estimating performance of a USA consulting organisation. It is shown that, with a coefficient of variation of 7.82%, the organisation is the leading non-contractor of those surveyed to date. Why this should be so may be because of the nature of the practice of construction cost consultancy in the USA. Although the nature of practice is evolving, the preparation of such pre-tender estimates continues to be a significant element of the service provided by USA construction cost consultants. Clients value the knowledge provided by the estimate as a tool for comparing the bids of competing contractors. Often it is the consultant's only involvement with a project and their ability to produce accurate estimates is the competitive edge which wins the commission to produce the estimate. USA practice is directly opposite to what might be called the 'United Kingdom model' of providing pre-tender estimates (the United Kingdom model largely obtaining in other countries, such as Australia, South Africa, Singapore and the Hong Kong SAR where procedures have been influenced by United Kingdom practice). In the United Kingdom such estimates are usually carried out by quantity surveyors. The quantity surveyor normally offers, and is engaged, to carry out a service running for the whole of the construction project (from initial feasibility planning through design development, bidding and contract administration), and there is no separate consultancy fee for preparing the pre-tender estimate. Indeed, if the project were to be aborted due to the estimate indicating a serious budget overrun, then no fee for this work would be due. In short, it is likely that the mind of the USA cost consultant is more sharply focused when preparing pre-tender estimates when compared to his United Kingdom counterpart.

The analysis then continues to seek a means of improving the estimating performance further by the empirical identification of factors influencing forecasting accuracy. The result of this is to show that, after partialling out the effects of confounding variables, year by year changes account for all the systematic errors that could be detected. These changes are then shown to be significantly correlated with the USA annual inflation rate and a regression model is used to examine the possible effects of adjusting for this in the estimation process. It is shown that a slight improvement is theoretically possible but probably not of practical value.

Estimating construction costs is not, therefore, accurate to within "a few percentage points" (a 5.19% average overestimate with a 8.23% coefficient of variation implies that estimates are correct to within 12.12% below and 22.50% above the lowest bid price for 19 out of 20 projects). Bearing in mind that the estimating performance analysed here is the very best achievable, the question has to be asked, "Is this good enough to support procurement decisions based on financial feasibility?"

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